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TYPESETTING

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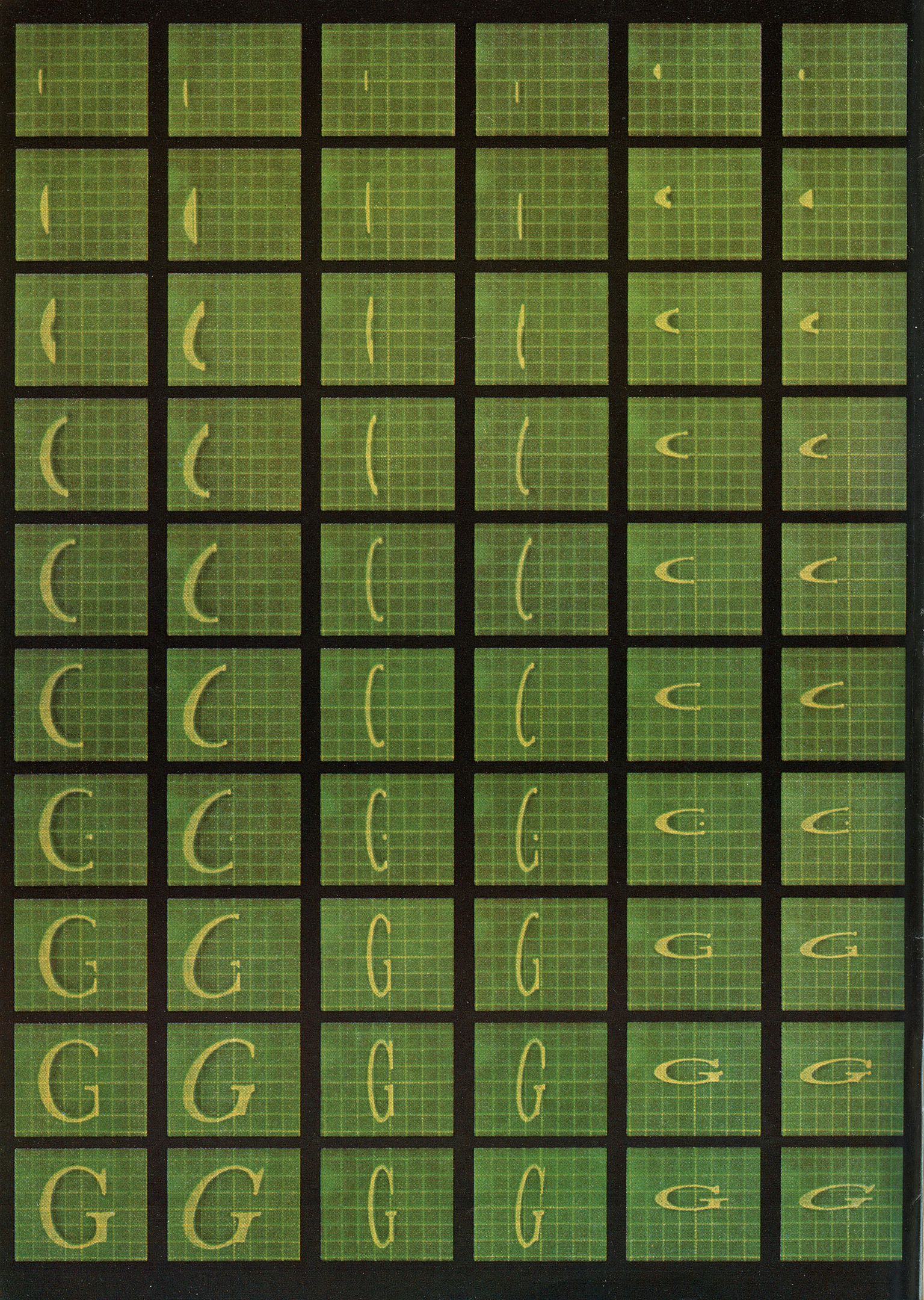


TYPESETTING

Electronic typesetting systems capable of "painting" as many as 10,000 characters per second on the screen of a cathode ray tube promise to have a revolutionary effect on the printing industry

by Gerard O. Walter

The art of printing is at least 1,200 years old, and in general practice it still follows basically the original method. Characters or images are formed in relief on supporting blocks or plates; the composition is then inked and printed on paper. The invention of movable type and stereotypes and the mechanization of the various steps in the printing process facilitated these operations but did not fundamentally alter the method. Printing is now, however, undergoing radical innovations, particularly in typesetting. Since 1948 we have seen the application of photography to this operation, leading to the wide use of photo-offset printing. Within the past three years a much faster technique has been developed: "typesetting" by an electron beam.

In the days of setting type by hand highly skilled compositors achieved remarkable speeds as high as one character per second; mechanical typesetters built since the turn of this century cast about five characters per second. Nowadays photographic typesetting machines that select the characters mechanically are capable of setting as many as 500 characters per second. In contrast, the new electronic method can produce up to 10,000 characters per second. In conjunction with a computer directing the operation this system is introducing a new order of speed and capability in the printing industry.

PHOTOMONTAGE on the opposite page was assembled in order to provide a demonstration of the technique employed to "paint" a character on the screen of a cathode ray tube by means of a moving electron beam. The photographs were selected from film strips of single letters formed by a simulated typesetting machine built by engineers at the Graphic Systems Division of RCA to demonstrate some of the capabilities of their system for electronic typesetting. In the actual RCA Videocomp machine the resolution is much better and the formation of the characters is too fast to capture photographically in this manner. Reading from left to right, the six capital *G*'s in the photographs at bottom are called roman, italic, condensed roman, condensed italic, expanded roman and expanded italic.

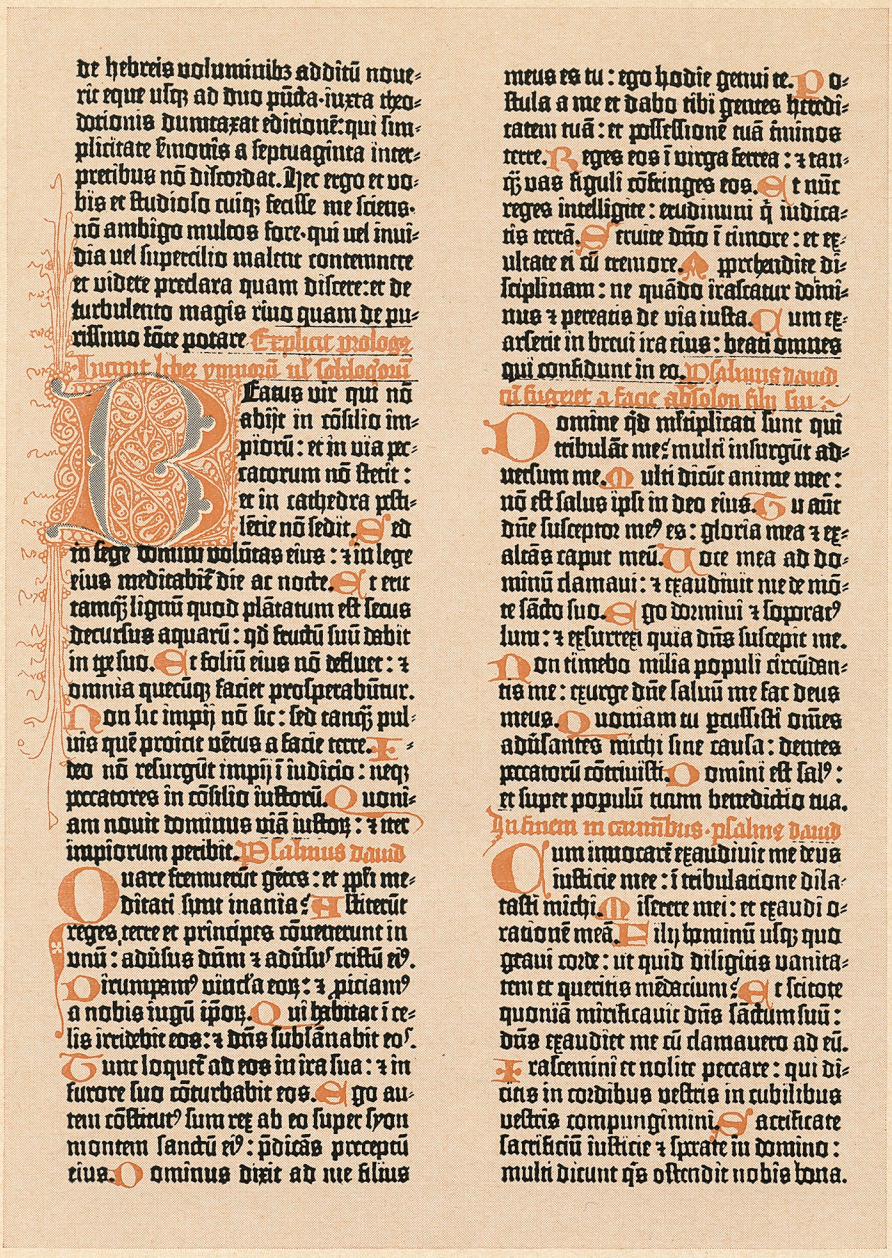
Early Printing Techniques

For background let us take a brief look into the history of the development of typesetting. Printing originated in China and was not introduced into Europe until several centuries later. The earliest printing tools and printed documents, found in China and Japan, are from the eighth century, and the oldest-known printed book is a Chinese work dated May 11, 868. The early printing was done from clay plates or wood blocks. The clay plates were made by scribing ideographs—symbolic pictures—in a flat slab of wet clay, drying the slab in an oven and then pressing soft clay into this hardened mold to form the "positive," or raised image, that was used for printing. Wood printing blocks were made by carving the surface of the block to produce the image in relief. Essentially these two elementary principles have been the bases for the various methods of producing type masters up to the present day.

In the 11th century a Chinese printer named Pi Shêng introduced flexibility into the composition of type masters by inventing movable clay type. Each unit was a small clay tablet bearing the relief image of a single ideograph. The type units were assembled for printing on a tray coated with resin that held them in place. Printers could now compose any message from the store of ideographs and use the units again and again to produce other compositions. Thus by the 11th century the basic devices for founding a printing industry had already been invented by the Chinese, and these developments soon became known in the West through Chinese contacts with the Arabs. Yet the Europeans did not take up and develop printing until more than 400 years later!

Curiously, it appears that a seemingly minor language technicality may have been largely responsible for this lag. The Chinese ideographs are all of about the same width; consequently Pi Shêng was able to make his clay type blocks of uniform width and use uniform spacing, so that they could be laid out simply and neatly in a regular order that formed a tastefully balanced plate, or page. In the Western languages the irregularity of the letters and other characters does not allow making the type size uniform. The characters vary in width, in height and, because of their different shapes, in their spacing.

To appreciate the importance of this complication, examine the page you are reading. You are quite aware of the visible type (there are about 6,000 characters in black on a full page of this magazine), but in all likelihood you are not aware of the fact that the page also contains a great deal of invisible type—the white spaces between letters, the spaces between words and the spaces between lines. For a compositor these spaces are as important as the characters themselves. He must produce them somehow by material means. The white space around each letter is provided by the fact that the type body (the block that carries the letter) is slightly larger than the letter itself, and the size of this body must vary with the letter so that the



HAND COMPOSITION of movable type was the technique devised by Johann Gutenberg to set the type for his 1456 Bible, a section of which is shown in this photograph. Gutenberg cast each character in relief on a metal block in a position such that when the blocks were put side by side, the spaces between the characters were tastefully balanced. The lines were "justified" by using blank blocks of various widths for the space between words.

spacing between letters fulfills requirements of legibility and aesthetics. The spaces between the lines are provided by leading. The spaces between the words present a prime problem of management for the typesetter: they are by no means standard but in each line are finely tuned—by the process called justification—so that the line comes out even at the right margin.

It was the skillful solving of the spacing problem that made Johann Gutenberg the most famous name in the history of printing and even gained him the reputation of being printing's inventor (at least in the West). The Gutenberg Bible, which he printed in his native city of Mainz in 1456, is a model of accurate and tasteful composition [*see illustration above*]. Using the Gothic style (derived from manuscript writing), Gutenberg produced movable type by casting each character in relief on a separate metal block. The character was not centered; each was cleverly placed on its block in a position such that when blocks were put side by side, the spaces between the characters were well balanced and there were no "holes" or concentrations of black in a word. This is indeed an art, requiring an aesthetic eye and meticulous care; even today, with all our technology, the placement of characters on their blocks is determined empirically by trials involving closer and closer approximations. Gutenberg also introduced the justification of lines of type by using blank blocks of various widths for the space between words. To set up a page he laid the blocks in a chase: a viselike holder that clamps all the blocks together.

Gutenberg's alphabet (in Latin) consisted of 73 characters (letters and numerals) and punctuation marks. Modern fonts of type usually contain 126 characters. A font is a complete collection of symbols in a particular design and size; its elements are the lowercase letters, capitals, small capitals, ligatures (letter combinations such as fi, ffi and fl), accented letters, numerals, punctuation marks, reference marks and other symbols. The size of the type is measured in "points"; in the U.S. a point measures approximately 1/72 inch. Each size of type comes in various thicknesses, ranging from light to bold. And a given design also embraces other variations, such as "condensed" and "expanded," roman (upright) and italic.

Among the creative printers who followed Gutenberg the names of several are immortalized in the designations of the type styles, or typefaces, they invented. Around 1470 a French printer, Nicolas Jenson, originated the Venetian style, which has since been developed in many variations. Between 1720 and 1726 William Caslon, an English artist, architect and stonemason, developed the typeface that bears his name. Another famous type style was designed by a similarly versatile Englishman, John Baskerville, about 1750. Perhaps the most distinguished of all type designers was Giambattista Bodoni of Italy, who in 1768 produced the type style, notable for its simplicity and cleanness, that is the most popular today.

Printing is now an industry of many separate crafts and specialties, which include the production of paper and inks, typesetting, engraving, press operations and of course the vast enterprise of publishing, to which the printing industry is intimately related. Although this article is primarily about typesetting, I should like to touch briefly on some of these related developments.

Paper, Ink and Type

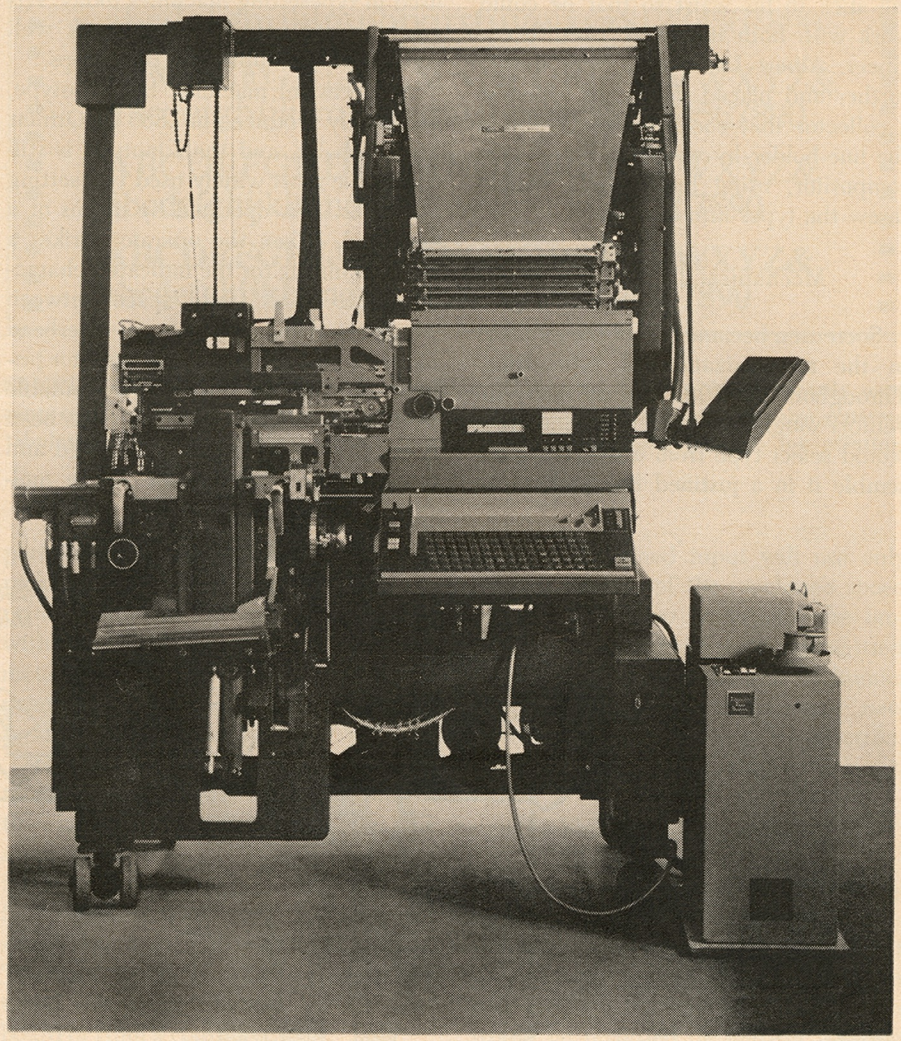
The invention and manufacture of paper had its beginning nearly 2,000

years ago in what is now a small, dirty pool of water at Leiyang at the foot of Heng Mountain in south central China. There the world's first papermaker, whose name is lost to history, originated the material by boiling bark, rags and discarded fishing nets and beating the stuff into a pulp. From the first century until the eighth papermaking was scarcely known outside China, but in the middle of the eighth century the Arabs learned the craft from Chinese prisoners captured in a battle at Samarkand. The Arabs rapidly substituted paper for parchment as a writing material, as is evidenced by many Arabic manuscripts on paper that date back to as early as the ninth century. They produced paper from linen at first and then from flax and other plant fibers, supplemented by rags. By the 12th century the manufacture of paper was established in Europe by the Moors who invaded Spain, and paper was being produced and used in Britain by the 14th century. The popularity of newspapers, pamphlets and letters of correspondence in the American colonies spurred papermaking in the new world; the first paper mill was built in Germantown, Pa., in 1690 by an ambitious papermaker from Prussia, William Rittenhouse, to supply the Philadelphia printer William Bradford. The U.S. has become the world's leading producer and user of paper, primarily for the publishing of newspapers, magazines and books.

Ink is considerably older than paper; it was produced in Egypt and China as early as 2500 B.C. The ancients at first made ink by mixing lampblack with a solution of glue or gum; later they resorted to a variety of other plant, mineral and animal substances, including "dragon's blood." Modern inks consist of a pigment such as a mixture of iron salt and tannin in a vehicle such as linseed oil, with an addition of oxygen-absorbing materials to hasten drying of the ink. For magazine publishing, where the printing must be done at high speed and on less absorbent paper, fast-drying inks that are dried by heat and evaporation have been developed. The composition of ink and its application have become a sophisticated technology with a considerable bearing on type design, as the flow of ink affects the thickness of the type image impressed on the paper.

In typesetting the first important physical improvement arrived in the 15th century: metal began to replace wood blocks for the type. The switch to metal type soon led to the use of matrices. Since the high cost of metal type made it impracticable to stock enough type to print an entire book, printers resorted to using their type to make a replica in lead for each page. The page was set in type, this assembly was pressed into a sheet of papier-mâché, the impression was then filled with hot lead, and the resulting plate of characters in relief served as the print master. The type itself, not having been inked, could be re-sorted and used again without cleaning. In the 19th century the invention of the rotary press for faster printing brought about the development of curved stereotypes, made in essentially the same way as the flat matrices, to fit on the cylinders of the rotary press. Machines for making matrices and stereotypes were built, and in 1837 a German physicist, Moritz Hermann Jacobi, invented the process of electrotyping, which by depositing a coat of copper or nickel on the print master improved its durability.

Meanwhile progress was being made in increasing the speed of typesetting. Gutenberg's idea of ligatures was extended to putting commonly used combinations of letters (such as ed, er, st, wh) and even entire syllables on a type



MECHANICAL COMPOSITION, an innovation introduced largely in the 19th century, has reached its highest point of development in modern typesetting machines such as the Mergenthaler Linotype Company's Elektron, depicted here. The Elektron, like the original Linotype machine invented by Ottmar Mergenthaler in 1885, can be operated directly by means of a keyboard; the modern version can also be driven by information on paper or magnetic tape. When the operator (or the tape decoder) depresses a key, the matrix for the indicated character (or a blank for the space between words) is delivered from an overhead rack to a line-collector. The line is justified by inserting expandable wedges. After the line measure has been filled the line of matrices is locked and transported to a chamber where molten metal is introduced under pressure. From the matrices as a mold the metal is cast into a line in one piece; after cooling the cast line is ejected into a tray. The matrices that formed the line are then returned to their individual compartments in the overhead rack through a sorting machine. Mechanical typesetters can cast five characters per second.

block, constituting what is known as a logotype. Using logotypes, a Viennese compositor named Leopold Weiss set type at the rate of 3,500 characters an hour in a contest in 1883. His typecase had 668 compartments (as against the ordinary font of 126). Only a genius could work with such a monster of a case, and one must marvel at the accomplishments of Chinese compositors, who even today have to work with a case containing up to 10,000 ideographs.

Other devices for accelerating setting by hand came into use. The inventive Danish compositor Christian Soerensen conceived the idea of tying the composing stick to his waist so that he could work with both hands. A Swedish engineer, Albert Lagerman, went a step further and placed under the typecase a collector that conveyed the types to the line-holder by way of a funnel; the compositor, using both hands, simply threw the types into the funnel.

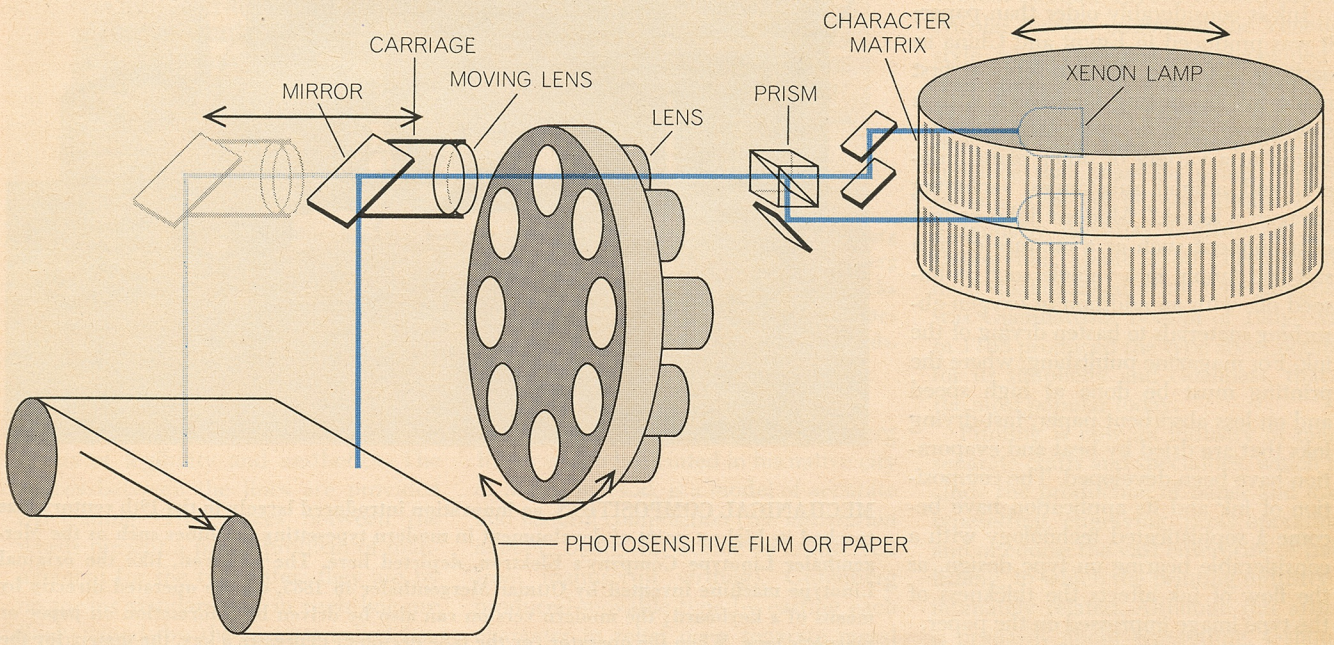
Mechanical Typesetting

Soerensen became one of the pioneers in the mechanization of typesetting. Throughout the 19th century many inventors sought to devise a machine that would select type from a magazine, assemble it in a justified line and return the types to their proper places in the magazine after the line was cast. Elaborate machines (one of which required no fewer than seven operators!) were built, but they fell short of acceptability. One of the main difficulties was the problem of mechanical identification of the types for setting and for later return to the origin. In 1849 Soerensen produced a device that essentially solved this problem. He notched each type body in a way that identified the character and used brass rods to select and guide the transport of the type. Soerensen's was the first machine that could both set and return type, and his notching idea is still used in typesetting machines today. His machine did not, however, work well enough to be adopted by printshops.

A successful machine, the Linotype, was finally produced in 1885 by Ottmar Mergenthaler, and the Linotype is still one of the most widely used typesetting machines. It is operated by means of a keyboard. When the operator strikes a key, the matrix for the indicated character (or a blank for a space between words) is delivered from an overhead rack to a line-collector. The operator justifies the line by inserting expandable wedges. After the line measure has been filled, the line of matrices is locked and transported to a chamber where molten metal is introduced under pressure. From the matrices as a mold the metal is cast into a line in one piece, and after cooling the cast line is ejected into a tray. The matrices that formed the line are returned to their individual compartments in the overhead rack through a sorting machine. While the metal line is being cast, the compositor is already assembling the next line with the keyboard.

The Linotype machine is well designed for tasks such as setting a newspaper, consisting of regular columns and relatively simple text; it is not well suited, however, for handling complicated, irregular formats, and it becomes a slow, cumbersome instrument when many special symbols must be inserted in the text or when many corrections are required. The machine is noisy and emits considerable heat from the molten metal. The latter inconveniences were avoided in the Monotype machine, which was developed at the turn of the century. In the Monotype instrument the typesetting is done in the first instance on paper tape.

The inventor of the Monotype was Tolbert Lanston. A clerk in the U.S. Pension Bureau, he took a cue from Herman Hollerith's development of punched cards for machine tabulation



PHOTOCOMPOSITION, a development of the 1940's and 1950's, is represented here by a schematic drawing of the Photon 713 optical system, a product of Photon, Inc. A cylindrical matrix containing all the characters in the form of photographic images carries the images past a stroboscopic lamp, which flashes the successively selected characters through a moving-lens system onto a photosensitive film, from which an offset printing plate is exposed. After the plate is developed only the desired character images remain. The plate is treated so that ink will be deposited only on the images; it is then inked and run against a rubber blanket that picks up the images and serves as the printing surface. This method is known as photo-offset printing. Phototypesetting systems can be operated either from a keyboard or from data on paper or magnetic tape. Fastest systems can set type at rates up to 500 characters per second.

of the 1890 Census and set out to apply the idea to typesetting. He reasoned that holes punched in a paper tape could represent the matrices for individual type characters and could specify the position in which each character should be placed in a line. The tape, punched by an operator at a keyboard, would be fed into a machine that would cast the type units and set them in the line according to the tape's instructions. With the help of John Sellers Bancroft, an engineer, Lanston eventually produced a successful machine. An operator punches the holes for the successive characters with the tape-perforating machine; the machine automatically adds up the width units as he proceeds and, before the end of the line is reached, it informs him what keys he must strike to insert word spaces of a width that will produce a full, justified line. When the line is completed, the punched tape is inserted in the casting machine tail end first (so that the line will be cast from right to left). In the casting machine the information in the tape selects matrices one at a time and causes each matrix to be pushed into a mold where a squirt of molten metal is injected to form the character or word space; the cast line is finally deposited on a galley. One such machine can keep up with two keyboards.

The Monotype machine owes much of its success to beautiful type designs by Frederic W. Goudy and Sol Hess. Several other machines, some successful and some not, contributed to the advancement of mechanical typesetting, among them the McMillan composing machine, the Rogers Typograph, the St. John Typobar, the Ludlow Typograph and the Intertype. Let us go, however, to the next major development in typesetting: the introduction of photographic processes in the 1940's and 1950's.

SAMPLE TYPEFACES produced by the RCA Videocomp include the commonly used fonts represented here. Electronic typesetting systems such as Videocomp can also generate tabular or columnar displays, drawings and eventually halftone pictures for printing.

Photographic Typesetting

There are several varieties of machine for phototypesetting, or photocomposition, as it is called. They differ in method of operation but all are based on the same principle. A matrix containing all the characters in the form of photographic images is scanned in one way or another with a stroboscopic lamp that flashes the successively selected images of characters through a lens onto a photosensitive plate [*see illustration on opposite page*]. After development of the plate only the character images remain. For photo-offset printing the plate is treated so that ink will be deposited only on the images; it is then inked, and the plate is run against a rubber blanket that picks up the images and serves as the printing surface. This system does away with the casting of raised characters in metal and the letterpress method of printing. A photo-offset plate can be produced quite quickly.

The use of the lens makes it possible to magnify the image and thus project the characters in various sizes from the same master matrix. The matrix can contain sets of characters in various typeface styles, any of which can be used simply by dialing to a desired setting. The machine can readily be operated by taped instructions, either from a keyboard or from a computer.

Phototypesetting machines can set type at rates of up to 500 characters per second. With a human operator at the keyboard, however, the machine is obviously limited to the rate of input by the operator. Including the various kinds of command that must be given the machine, a good keypunch operator cannot do much better than about one and a half characters per second. It is possible to multiply this rate by hooking several keyboards into the machine with operators working simultaneously, but even so their combined input will use only a small fraction of the machine's speed capacity. The two limitations—the limited speed capacity of the machine itself and the limited rate of input by human operators—prompted the current new development: typesetting by electronics with a computer providing the input.

Electronic Typesetting

Suppose one designed a cathode ray tube (similar to the kind used in television sets and other display devices) that would paint characters on the screen and produce lines of text that in turn would be recorded on film for printing by the photo-offset method. Characters could be formed by swinging the electron beam to make short, parallel strokes so fine and spaced so closely together that the image would appear solid [*see illustrations on page 68*]. Several companies in the electronic and printing fields began to explore this inviting concept almost simultaneously, and since 1966 a number of successful machines have been produced and demonstrated. The companies include RCA (which has produced several systems based on ma-

chines first developed by the Dr.-Ing. Rudolf Hell Company in Germany), the Mergenthaler Linotype Company (marketing a machine developed by K. S. Paul of Britain and one developed in cooperation with CBS Laboratories), the Intertype Company and the International Business Machines Corporation (distributing a machine developed by Alphanumeric Incorporated).

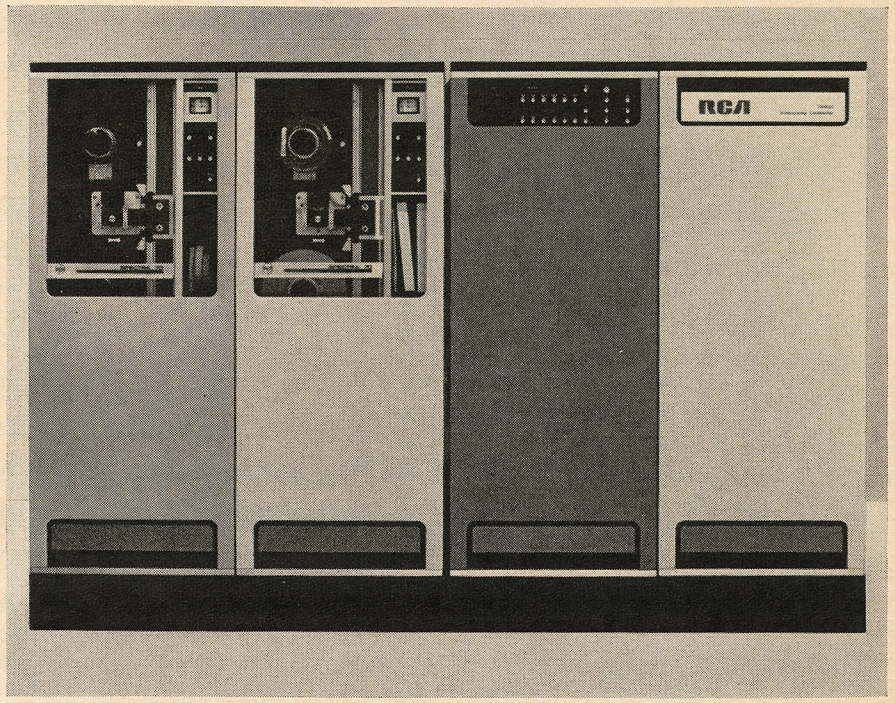
In some of these machines the character is painted with vertical strokes, in others with horizontal strokes. The screen is an optically flat disk coated with layers of aluminum and phosphor. With each stroke the electron beam produces an extremely fine line, less than a thousandth of an inch wide, on the screen; some systems pack the lines as closely as 1,200 strokes to the inch. The stroke, produced by switching the moving beam on for a brief instant, is of course very short—no longer than the height or the breadth of the members that form the type character. Since the beam can move at speeds as high as 10,000 inches per second or even faster, it paints the characters very rapidly.

The RCA machines, some of which can generate characters as large as an inch and a half in height, operate at speeds from several hundred to several thousand characters per second, depending on the model and the size of type. A number of the RCA machines are already in use in the printing industry. The Alphanumeric machine generates type at up to 6,000 characters per second. One of the Mergenthaler Linotrons can compose 10,000 characters per second. It will probably be possible to develop electronic typesetters with speeds of 60,000 or more characters per second.

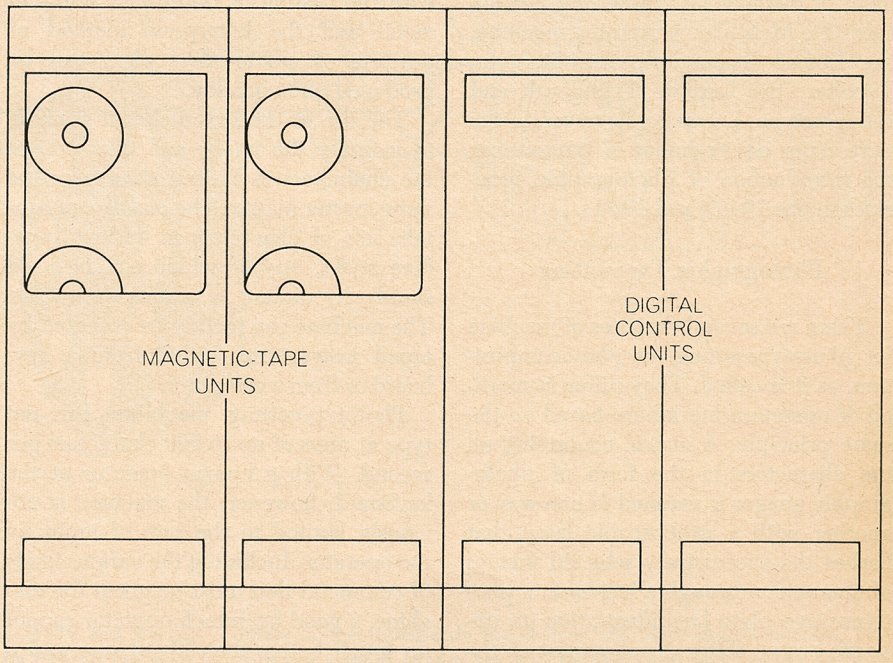
The machines record the electronically produced characters on film by various methods. For projection to the film some machines use stationary lenses and others moving lenses to pick up the characters as they are painted on the screen; some use continuously moving film; some photocompose an entire page of text at a time on stationary film; others advance the film for every line. One of the virtues of the electronic system is that the beam can paint not only type characters but also any kind of graphic material; it can easily generate tabular or columnar displays, drawings and eventually even halftone pictures for printing.

The high-speed electronic typesetter not only lends itself to operation by computer but also actually demands it. To begin with, the system requires a computer-type memory bearing fully detailed instructions for the printing of each character, so that the keyboard operator need not punch in on-off signals for the multitude of strokes the electron beam must make to form the character. Thus one "box" in the memory carries the instructions for forming the letter *a*, another for *b*, and so on. Entire fonts of type in various styles are stored in the memory, and any font can be selected simply by pressing the proper identifying keys.

This is merely the first step in the

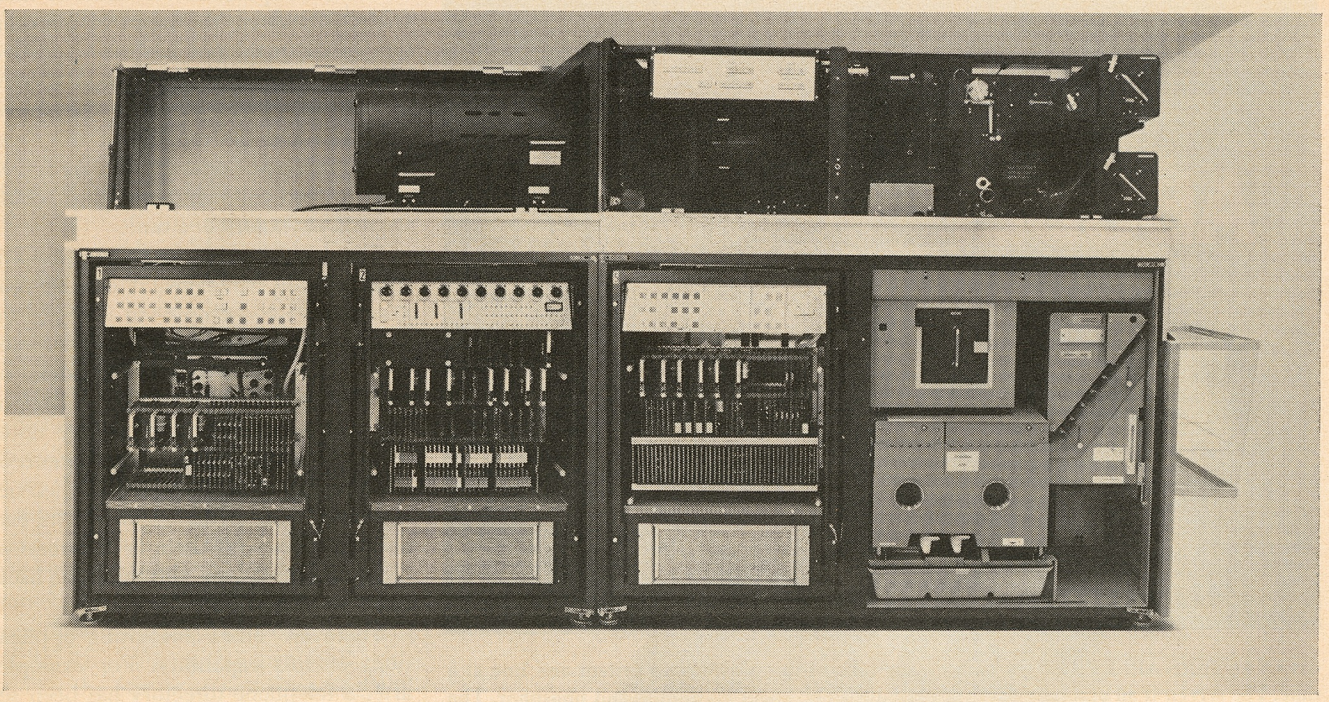


RCA VIDEOCOMP is a high-speed electronic typesetting system based on machines first developed by the Dr.-Ing. Rudolf Hell Company in Germany. Machines such as the Video-

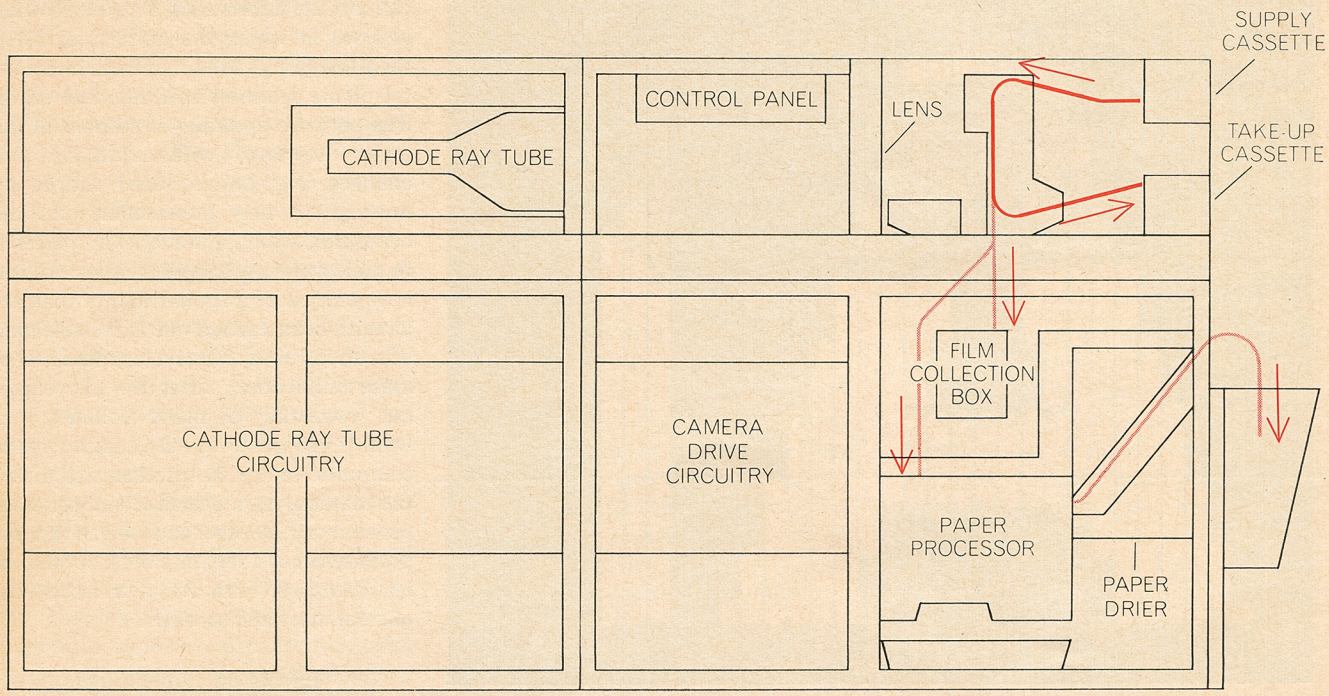


SCHEMATIC DRAWING of the Videocomp system shows the relationship of the essential components. The two tape units at extreme left submit the text in digital form to the system. The system can also handle an input of digitized information from as many as 32 keyboards at a time. The next two units comprise a digital computer and a memory, which contains

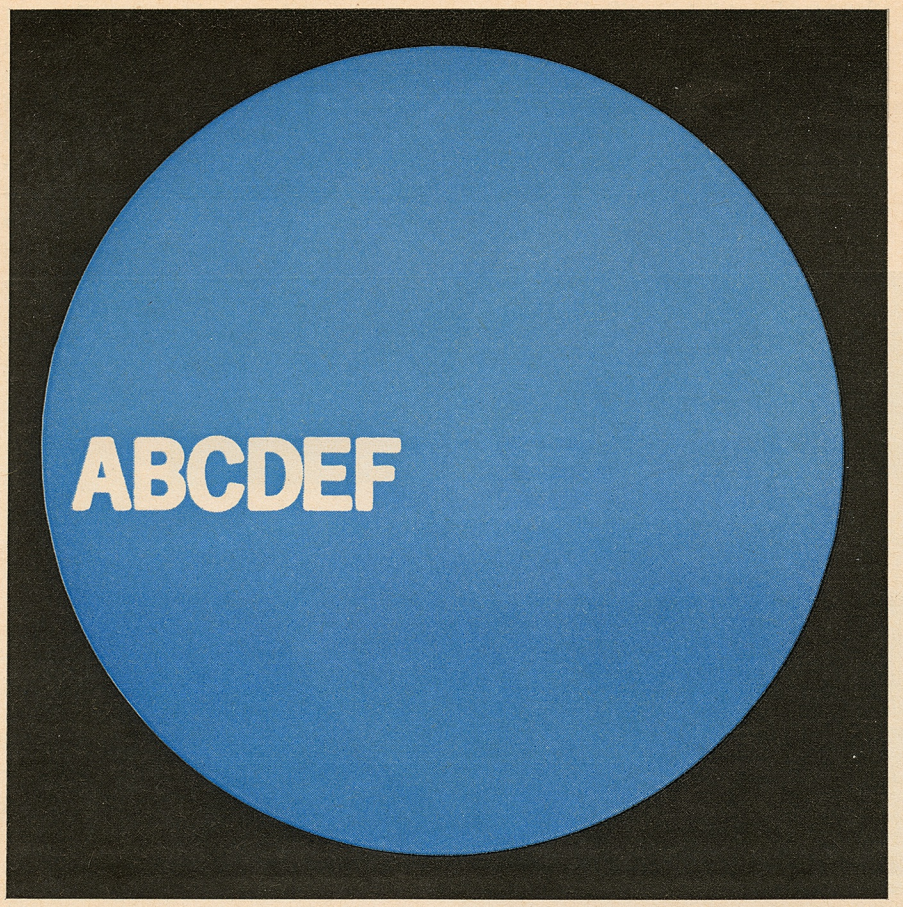
computerization of the machine's operations. In composing text the keyboard operator need only type on steadily as if he were writing one long line; the computer, which has the width of each character, a word dictionary and a set of rules stored in its memory, will break up the typed text into justified lines, even hyphenating a word at a proper syllable break when it would run over the line. With a brief signal identifying a stored string of commands the operator can cause the computer to start a new chapter in a book, calling for the start of a new page, selecting the style and size of type for the chapter head, specifying the placement of the head and the spaces around it and indenting the first line of the following text. The computer can perform almost all the functions of formatting, creating runarounds for illustra-



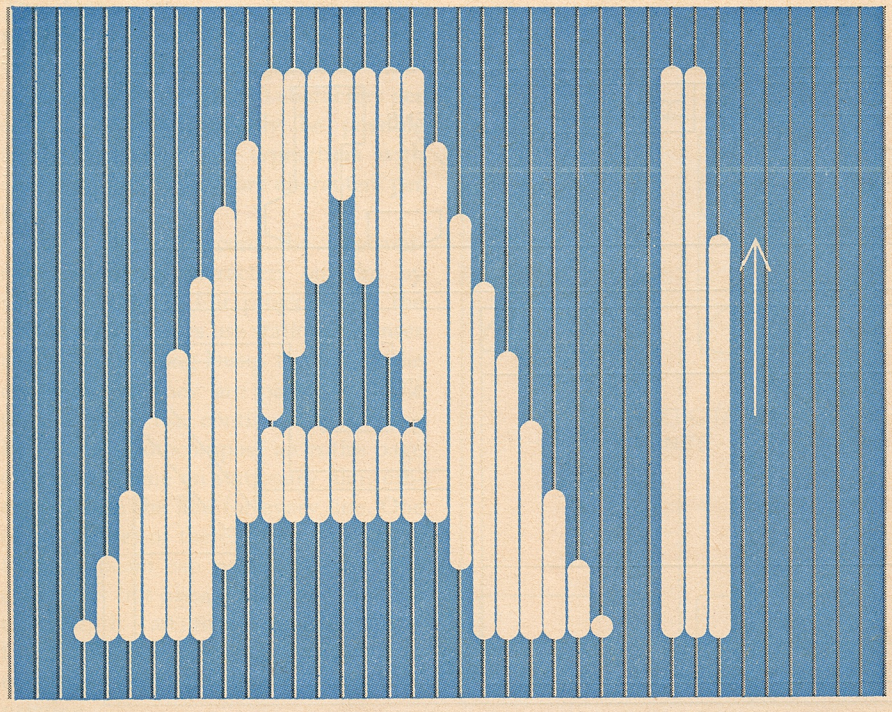
comp operate at speeds from several hundred to several thousand characters per second, depending on the model and the size of the type. A number of electronic typesetting machines, made by various companies, are already in use in the printing industry.



stored programs for printing each character. The computer can also break the text into justified lines, hyphenate words at proper syllable breaks and carry out other tasks of makeup and editing. The electronically produced characters are painted on the cathode ray tube (*right*). The images on the tube are projected by means of a stationary lens onto photosensitive film or paper, which advances line by line or page by page. The developed paper is used mainly for proofs; developed film is suitable for making printing plates.



CHARACTERS APPEAR on the cathode ray tube of this Videocomp system one line at a time. The screen is an optically flat disk coated with layers of aluminum and phosphor. The photograph was made with the aid of a mirror inserted between the screen and the lens.



CHARACTER IS PAINTED on the cathode ray screen with closely spaced vertical strokes. With each stroke the electron beam produces an extremely fine line, less than a thousandth of an inch wide; the lines can be packed as closely as 1,200 to the inch. The line is produced by switching the moving beam on for as long as it takes to traverse the height of the character at that point. The beam can move at speeds greater than 10,000 inches per second.

tions, dividing the text into columns and pages, inserting page numbers and carrying out other tasks of makeup.

Considerable work has been done on the development of detailed programs for typesetting and other functions, and RCA has invented a special language that enables printers to communicate with the computer in the terms of their trade. Moreover, the input of information to the machines has been speeded up greatly. Besides simplifying the work of the individual operator, the stored programs and the rapidity of the typesetting machine's operations make it possible to feed commands into a machine from 32 keyboards at a time.

The computer has begun to perform some editing functions. It can be programmed, for example, to compile indexes, bibliographies, lists of footnotes and other specified lists for books or technical publications. As the setting of the text proceeds, the computer notes the key terms or other specified items of information, stores the places of their occurrence in its memory and at the end automatically sorts them in alphabetical order and directs the setting of the list it has compiled.

There are other interesting applications of this capability. For example, after a telephone directory has been set in the usual form with the subscribers' names in alphabetical order, the computer, with the list stored in its memory, can sort the information to produce other editions in which the entries are listed by districts and street numbers or by the telephone numbers in numerical order. The periodic updating of editions of the main directory, with additions and changes, can be produced simply by putting the new information into the computer, which automatically places it in the correct alphabetical order. Another operation of a similar nature that has already been carried out is the selection of sections from an encyclopedia for separate publication. After the encyclopedia, consisting of many volumes, has been keyboarded into the computer, the computer under instruction withdraws the material on a specified subject from its memory storage and sets it up for publication as a separate book or pamphlet, complete with its own index, list of references and so forth.

Effects on Publishing

The effects of electronic typesetting *cum* computer on publishing are likely to be substantial. The public hunger for printed information is seemingly insatia-

ble; historically the supply has generally run behind the demand. Within the past decade book publishing has doubled in the U.S., and the sales of newspapers and periodicals have increased by 50 percent or more. Printing, the eighth-largest industry in the nation, is growing faster than other manufacturing industries. Its total sales now amount to more than $15 billion a year, of which $5.5 billion is spent for newspapers, $5.3 billion for general printing, $2.5 billion for periodicals and $2 billion for books.

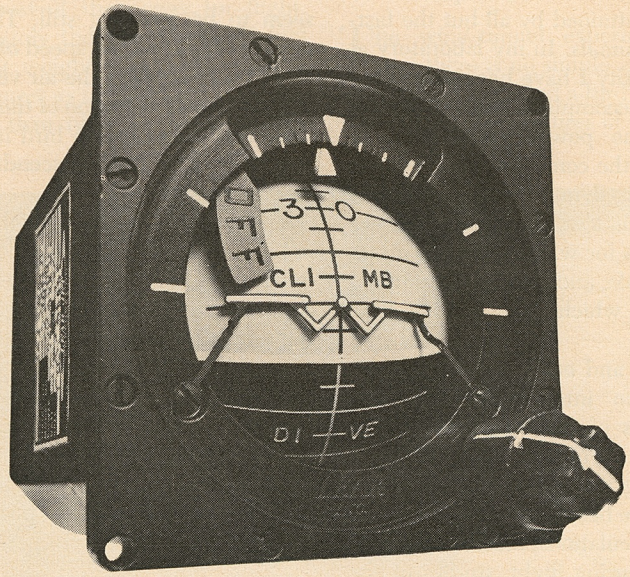
Electronic typesetting will undoubtedly foster a considerable increase in the demand for and volume of printed material, since it reduces the cost of printing and speeds up the output. One can foresee other consequences, however, that will be more dramatic. These have to do with a predictable acceleration of the pace of printing.

The new electronic techniques have cut the publishing time for a complicated college text or a technical book from a year or more (after submission of the completed manuscript) to less than three months. This means that up-to-date texts can now be made available rapidly to universities, colleges and schools, and technical handbooks can carry current information. For newspapers and periodicals the effects of rapid printing will be even more significant. It has already been demonstrated that a full newspaper page, including pictures, can be set up electronically in less than five minutes; thus the news can become available in print almost as quickly as the bulletins on the radio or television.

There is a prospect as exciting as rapid printing itself. The electronic system makes it possible to distribute publications speedily on a continental scale without the need of shipping them in the form of vast, slow-moving quantities of paper. The content of a newspaper or a magazine, composed electronically in a central office, can be transmitted by means of telephone lines or wireless channels to satellite plants around the country, or even around the world, where local electronic typesetters, activated from the central source, will produce plates for printing on local stocks of paper. Thus readers in New York, Chicago, San Francisco, Honolulu, London, Tokyo and other points will be able to read the same newspaper or magazine at the same time. Truly national dailies, which in each city will include local news and features in space reserved for the purpose, will become a practicable proposition in the U.S. for the first time.

If Hi-Efficiency Low-Reflection coatings work so well on aircraft instruments,

why can't they work on other things, too?



They can. SLR and HELR vacuum-deposited coatings by Liberty Mirror may be used to increase the light transmission of any optical system including photographic lenses. They are more expensive than magnesium fluoride coatings that are now being used, but are twice as efficient in light transmission. They are now being used on aircraft instruments to eliminate reflections.

Vacuum-deposited coatings of aluminum, chrome and gold have many uses such as front-surface mirrors, neutral filters, transparent mirrors, Hi-Efficiency beam-splitting dichroic mirrors and filters. Metallic and transparent electrically conductive coatings are available for resistance heating, IR reflecting and RF shielding applications.

Applied to glass, optical parts, metal, epoxy or plastic, the coatings are used in such varied products as scientific and optical instruments, lasers, computers, outer-space vehicles and missiles. Technical data sheets and prices available on all coatings. Liberty Mirror, Brackenridge, Pennsylvania 15014.

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THE AUTHORS

BYRD C. CURTIS and DAVID R. JOHNSTON ("Hybrid Wheat") are with Cargill, Incorporated; Curtis is head of the hybrid wheat development program at Cargill Research Farms in Fort Collins, Colo., and Johnston is a wheat breeder. Curtis received his bachelor's degree in agronomy at Oklahoma State University in 1950, his master's degree in agronomy at Kansas State University in 1951 and his Ph.D. in plant breeding and genetics from Oklahoma State in 1959. He was a member of the staff at Oklahoma State until 1963, working on the breeding of wheat, oats and barley; he then was appointed associate professor at Colorado State University and director of wheat research for the state of Colorado. He joined Cargill in 1967. Johnston, who was graduated from the University of Massachusetts in 1952, was a research worker at the University of Minnesota from 1956 to 1967, when he took up his present position.

LARRY FALLER ("Relaxation Methods in Chemistry") is assistant professor of chemistry at Wesleyan University. "I spring from the most fertile soil for scientists—the Middle West, a nonprofessional family," he writes. Recalling "an amusing article" in *The American Scholar* on "the conformity of supposedly nonconforming academics," Faller says that "like an embarrassing number of my colleagues, I supported Eugene McCarthy, espouse black power, read *The New York Times*, drive a Volkswagen, live in an antique house, sing Schubert lieder accompanied by my wife (when no one is listening), play tennis and squash and sail." Faller was graduated from Wabash College in 1958, received advanced degrees from Yale University in 1959 and 1963 and spent two years as a postdoctoral fellow at the Max Planck Institute in Göttingen.

HENRY DE LUMLEY ("A Paleolithic Camp at Nice") is professor at the University of Aix-Marseilles, director of its Laboratory of Human Paleontology and Prehistory in Marseilles and a senior research associate of the French National Center for Scientific Research. He has participated in a number of excavations at lower and middle Paleolithic sites in southeastern France. Of one at Vallonnet Cave he writes: "These excavations revealed for the first time man's presence in Europe at the dawn of the Quaternary." Another excavation involved caves that are now under the waters of Villefranche Bay but were above water and had human inhabitants during the last glaciation.

GERARD O. WALTER ("Typesetting") is chief engineer in the Graphic Systems Division of RCA. He writes: "I was born in Vienna, the youngest of three sons of the owner of a prominent Austrian electrical manufacturing and retailing organization, who was also a member of the Austrian cabinet. The political turmoil of the late 1930's in Europe caught up with my family and resulted in my matriculation at St. John's University in Poland rather than the Vienna Institute of Technology." Later he received advanced degrees in mechanical engineering and physics at the Institute of Technology in Zurich and at the University of Zurich. Walter came to the U.S. in 1946 and for six years operated his own engineering firm, dealing in optical tooling and automation equipment. When phototypesetting became practical, he joined a firm making automatic phototypesetting machinery. He holds a number of patents in the field and in such other areas as microfilming systems, data retrieval, image manipulation "and even," he writes, "paper-handling machinery in the printing field."

VANCE A. TUCKER ("The Energetics of Bird Flight") is associate professor of zoology at Duke University. "My active interest in bird flight," he writes, "began during an airplane trip when I saw a flock of birds flying at 12,000 feet over the Aleutian Islands. I wondered how high birds could fly, but at the time I had no way of studying flight in the laboratory. A few years later I built a small wind tunnel and found that budgerigars could be trained to fly in it. One bird learned to wear an oxygen mask when flying at simulated high altitudes. It was an easy matter to reverse the flow through the mask and measure the bird's metabolic rate." Tucker was graduated from the University of California at Los Angeles in 1958, obtaining his master's degree at the University of Wisconsin in 1960 and his Ph.D. from U.C.L.A. in 1963. Since his first experiments he has found that several kinds of birds will fly in wind tunnels, and he is investigating a number of aspects of their aerodynamics and physiology.

RONALD K. LINDE and RICHARD C. CREWDSON ("Shock Waves in Solids") are at the Stanford Research Institute; Linde is director of the Poulter Laboratory for High Pressure Research and Crewdson is chairman of the shock and high-pressure physics department of the laboratory. Linde, who joined the institute in 1964, was graduated from the University of California at Los Angeles in 1961 and received his master's degree and Ph.D. from the California Institute of Technology in 1962 and 1964 respectively. He is the author of more than 20 papers in the field of solid-state physics. Crewdson was graduated from Lafayette College in 1961 and obtained his Ph.D. at Cal Tech in 1967. In addition to his research in shock-wave physics he is interested in industrial applications of the work.

NATHAN SHARON ("The Bacterial Cell Wall") is the Joseph and Sadie Danciger Professor of Molecular Biology in the department of biophysics at the Weizmann Institute of Science in Israel. Born in Poland, he emigrated with his family to Israel (then Palestine) in 1934. He studied at the Hebrew University in Jerusalem, where he received his master's degree in 1950 and his Ph.D. in 1953. In addition to his research, which deals mainly with proteins and carbohydrates, Sharon does a great deal of science writing for general audiences, and for some time he has edited a weekly radio program on advances in science. He is also the scientific editor of *Mada* ("Science"), a general science magazine published in Hebrew. Apart from his work Sharon enjoys stamp collecting and swimming.

CHARLES R. MICHAEL ("Retinal Processing of Visual Images") is assistant professor of physiology at the Yale University School of Medicine. He received his bachelor's degree from Harvard College in 1961 and remained at Harvard for his Ph.D., which he obtained in 1965. As a graduate student he had what he calls "a rewarding experience" in his informal association with David H. Hubel and Torsten N. Wiesel, who have done much work on visual processing. For three years after obtaining his doctorate Michael was a postdoctoral fellow at Johns Hopkins University, where he worked with Edward F. MacNichol, Jr., a noted investigator of visual pigments and color vision.

DOROTHY ZINBERG and PAUL DOTY, who in this issue review *The New Brahmins: Scientific Life in America*, by Spencer Klaw, are respectively a postdoctoral fellow at the University of London and professor of chemistry at Harvard University.